TECHNICAL REPORT

Contract Title:	Infrared Algorithm Development for Ocean Observations with EOS/MODIS
Contract:	NAS5-31361
Type of Report:	Quarterly
Time Period:	January 1994-March 1994
Principal Investigator:	Otis B. Brown RSMAS/MPO University of Miami 4600 Rickenbacker Causeway Miami, Florida 33149-1098

MODIS INFRARED ALGORITHM DEVELOPMENT

A. Near Term Objectives

A.1. Continue interaction with the MODIS Instrument Team through meetings and electronic communications.

A.2 Continue algorithmic development efforts based on experimental match-up databases and radiative transfer models.

A.3 Continue evaluation of different approaches for global SST data assimilation and work on statistically based objective analysis approaches.

A.4 Continue evaluation of high-speed network interconnection technologies.

A.5 Provide investigator and staff support for the preceding items.

B. Overview of Current Progress

B.1 January-March 1994

Activities during the past quarter have continued on the previously initiated tasks. New work is going on in the areas of radiative transfer modeling, studies to understand the impact of temperature inversions on retrieved surface temperatures and generation of model based retrieval algorithms; continuing discussions on IR calibration/validation as part of the MODIS Ocean Science Team cruises effort; and work on implementation of a design and implementation for a wide area network based on ATM technology. Previously initiated activities, such as additional definition of the ATBD data flows and other team related activities, are ongoing.

B.1.1 Radiative Transfer Modeling

Preliminary evaluation of LOWTRAN (Selby *et al*., 1978) and Rutherford Appleton Laboratory (RAL) radiative transfer models was initiated (Llewellyn-Jones *et al*., 1984). A. Zavody (RAC) furnished us with a version of the radiative transfer code which was validated against a profile supplied by P. Minnett (Brookhaven National Laboratory). We find that the RAL code is much easier to use and seems to provide more accurate simulations due to the pressure-dependent band absorption models employed. Thus, our MODIS radiative transfer modeling effort will utilize the RAL codes for current and future work.

A necessary prerequesite to developing a representative global ensemble of retrieval cases is to have a quality-controlled set of radiosonde observations with large areal extent and full annual cycle coverage. We have obtained a set of 1200 profiles from RAL, which was originally put together by NOAA/NESDIS, that provides such coverage (Fig. 1). As can be seen, there is reasonable coverage for tropical mid-latitude and polar regimes.

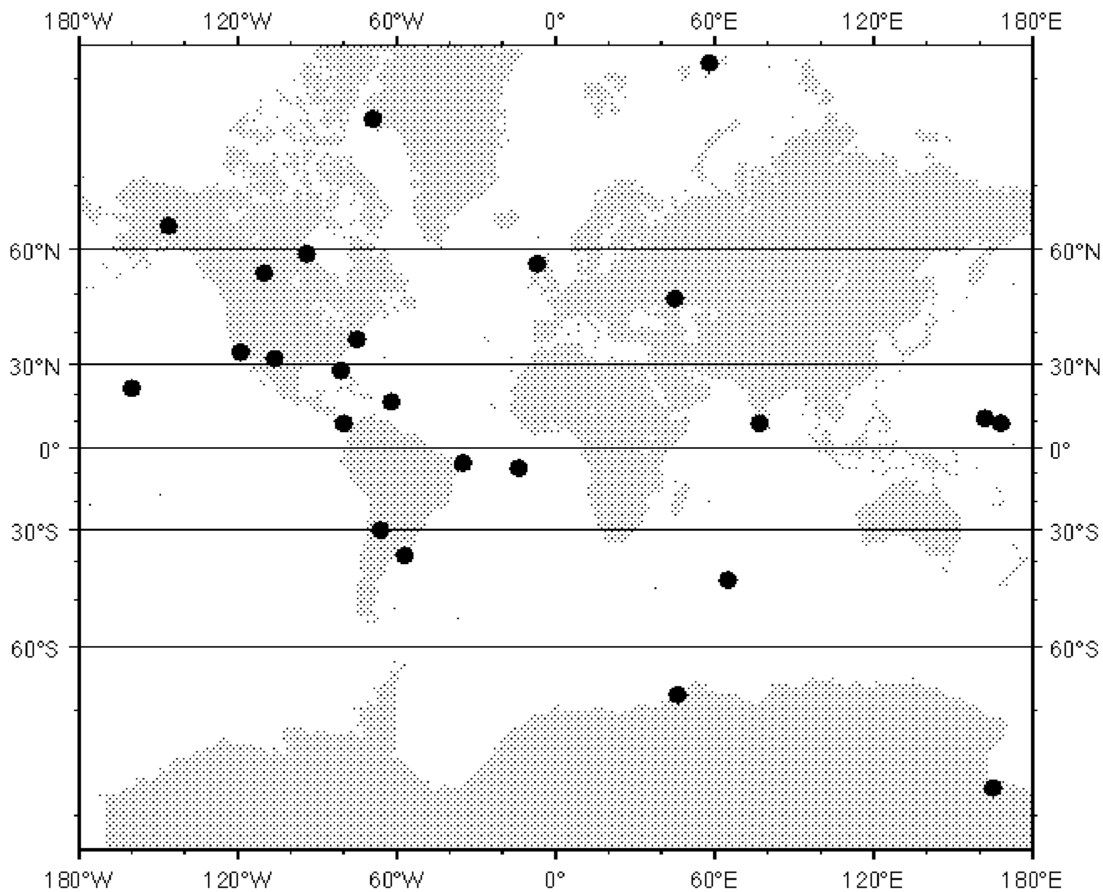

Fig. 1. Radiosonde sites in NOAA/NESDIS profile database. 1200 profiles are available from the 24 sites. The location in the Southern Indian Ocean is only an indicator for a number of ascents taken from an FSU research vessel at various locations in this region.

Examples of profiles at four sites are shown in Fig. 2 for January. The profile taken at (77°N, 69°W) on the Greenland coast illustrates a problematic aspect of doing atmospheric corrections in polar latitudes, or more generally with low level inversions.

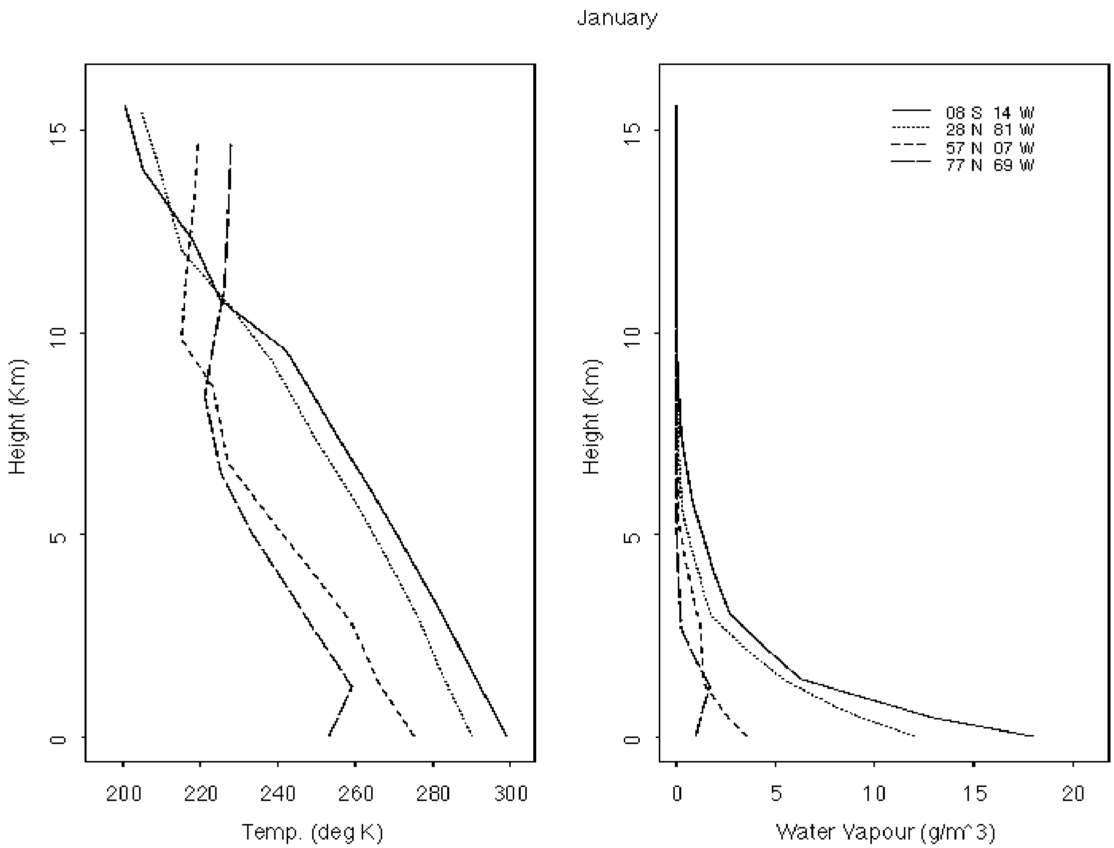

Fig. 2a,b. Temperature and humidity profiles for January at selected sites from the NOAA/NESDIS Radiosonde Profile data set. The four sites are located at: (8°S, 14°W); (28°N, 81°W); (57°N, 7°W); and (77°N, 69°W), respectively.

Preliminary comparisons of model and retrieved results indicate good agreement with the *in-situ* comparison database for band-temperature differences as a function of surface temperature and water vapor concentration. Fig. 3 illustrates the general trends for band differences as a function of water vapor concentration derived from modeling results.

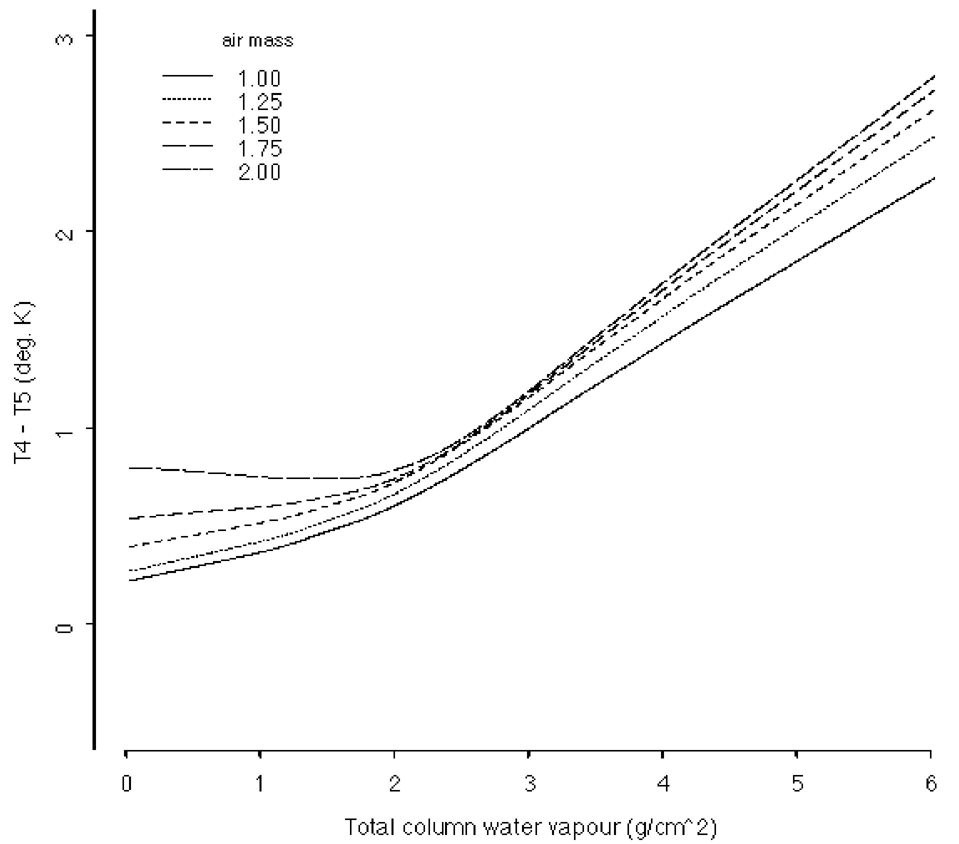

Fig. 3. Radiative transfer modeling results from the RAL model. Differences between AVHRR bands 4 and 5 (10-11 µ, 11-12 µ) were determined for 5 scan angles and the ensemble of near-ocean radiosonde sites (from the NOAA/NESDIS profile set). A robust estimation was used to provide regressions of band temperature differences *vs.* column water vapor concentration.

Notice that there is little correlation between band temperature difference and water vapor at cumulative water vapor concentrations below 2g*cm^{-2}. Above 2 gm cm^{-2} water vapor concentrations, there exists a strong relationship with band temperature difference. This suggests that atmospheric correction in polar and/or dry mid-latitude regimes is not straightforwardly parameterizable in terms of a simple band difference. It also suggests that simple linear relationships between water vapor and band temperature differences, as used by workers, are incorrect.

B.1.2 Algorithm Development Efforts Based on Experimental Match-up Data bases

Work has continued and good progress has been made in terms of evaluating a hierarchy of algorithms for atmospheric correction of the infrared retrievals. The lowest order algorithm in the hierarchy is one based on the McClain MCSST formulation. This was taken as a base to test all other implementations. Two implementations have been extensively studied, one based on the work of Walton (NLSST) and the other a variation on the NLSST approach where a piece wise set was used for correction (Evans/NLSST). A final version of the Evans/NLSST algorithm was selected for processing of the 1988 Pathfinder SST data set. This algorithm gives RMS values of approximately 0.5C based on global monthly composite datasets.

The major limitations in the current AVHRR system involve several issues: (1) instrumental calibration, (2) the NEΔT of the instrument, (3) the impact of water vapor on the opacity of the 10/11 µ windows for tropical atmosphere aerosols, and (4) skin *vs.* bulk temperature differences. MODIS offers significant improvements in the first three of these areas. We still need to evaluate the impact of aerosols and skin *vs.* bulk variances on the overall MODIS retrieval system accuracy.

B.1.3 ATBD

There has been limited work in the last quarter on the ATBD. Efforts have focused on improving the definition of the match-up database characteristics and on defining networking needs for post launch calibration/validation activities. Dr. Robert Evans has integrated our estimates into his ATBD data flow estimates.

B.1.4 Wide Area Networking

Efforts continue to establish an experimental wide area high speed network between the University of Miami, Oregon State University and the Naval Research Laboratory. ATM switches have been ordered for each site (through non-EOS funding) and installation is now expected in late May or early June. Advanced discussions are ongoing with NRL/DOD, the two universities, and MCI, to install a 45 Mb (DS-3) network between the three sites and have it operational by late May/ early June, 1994.

Currently the following experiments are planned:

(1) Demonstration of WAN-ATM connectivity between the three sites (SVC access);
(2) Provision of near real time infrared observations from AVHRR systems to OSU for data assimilation from Miami using objective analysis codes developed at Miami;
(3) Model visualization and objective analysis at Oregon State (on the OSU CM-5);
(4) Integration of near real time buoy and tower data (via NRL) with satellite data (Miami) and model data (OSU); and
(5) Visualization of combined data sets and analysis in near real time of model *vs.* satellite *vs. in situ* observations.

Preliminary results of this activity are expected by fall.

C. Investigator Support

January	W. Baringer
	J. Brown
	O. Brown
	G. Goni
	S. Walsh

February	W. Baringer J. Brown G. Goni A. Kroger
March	W. Baringer J. Brown G. Goni G. Halliwell E. Ryan

D. Future Activities

D.1 Current:

D.1.1 Algorithms

a. Continue to develop and test algorithms on global retrievals
b. Evaluation of global data assimilation statistics for SST fields
c. Continue RT modeling using RAL and AECRL
d. ATBD updates (as needed)
e. Implement ATM based network test bed
f. Continued integration of new 100 Specmark+ workstations into algorithm development environment

D.1.2 Investigator support

Continue current efforts

E. Problems

No new problems to report.

REFERENCES

Llewellyn-Jones, D.T., P.J. Minnett, R. W. Saunders and A.M. Zavody, 1984. Satellite multichannel infrared measurements of sea surface temperature of the N.E. Atlantic Ocean using AVHRR/2. *Quart J.R. Met. Soc*, **110**: 613-631.

Selby, J. E. A., F. X. Kneizys, J. H. Chetwynd Jr., R. A. McClatchey, 1978. Atmospheric Transmittance/Radiance: Computer Code LOWTRAN 4. AFGL-TR-78-0053, Environmental Research Papers, No. 626. Available from NTIS.